Barometer reading

MK 2 precision aneroid barometer (photo by G. Allen, Met Office)

The following text is based on an aneroid barometer reading, if the reading is taken from another kind of barometer, please use corrections as advised by your PMO or Meteorological Service.

In general, the aneroid barometer should be set to read the pressure at the level of the instrument. On board ships and at fixed sea stations (rig, platform) however, the instrument may be set to indicate the pressure at Mean Sea Level, provided the difference between the station pressure and the Mean Sea Level pressure can be regarded as constant. The reading should be corrected for instrumental errors. If the pressure reading is not indicating the pressure at Mean Sea Level, this program will correct the (instrument error corrected) reading to Mean Sea Level. The computed and automatically applied Height correction (sometimes called altitude correction or reduction constant) depends on the information provided by the observer.

Mintaka Star

Fuess aneroid barometer (photo KNMI)

Vaisala PTB330

Barometer check

Barometers and barographs should be checked as frequently as possible against standard instruments on shore at least once every three months. A permanent record of all such checks should, if possible, be attached to the instrument, and should include such information as the date of the check, temperature, and pressure at which the check was made. It is particularly important that barometers and barographs be checked as frequently as possible, because of possible zero drift, especially when the instruments are new.

The principle of the aneroid barometer was first suggested in 1698 but no useful instrument was constructed until 1843. The aneroid barometer consists of a circular metallic chamber exhausted of air and hermetically sealed. Variations of atmospheric pressure produce changes in the dimensions of the vacuum chamber and these changes are magnified mechanically, optically or electrically so that the atmospheric pressure may be read on a convenient scale.

The majority of aneroid barometers indicate the pressure by means of a pointer which rotates around a graduated dial. The vacuum chamber, usually called the aneroid capsule, has to provide the force needed to move the pointer and this prevents it from responding freely to pressure variations. This type of instrument is useful in showing pressure changes and some of the better quality instruments are suitable for all pressure readings. The aneroid has the advantage that, unlike the mercurial barometer, it does not suffer from 'pumping', although it does rise and fall slightly with change of height of the ship in the waves of a seaway.

Precision aneroid barometer

The Met. Office standard instrument is the type of precision aneroid barometer (PAB) in which the force required to operate the indicating mechanism is provided by the observer, allowing the capsule to respond freely to pressure changes. The sensing element is a stack of three disc-type aneroid capsules fixed to the inside wall of a cast metal box. Some magnification of the capsule movement is provided by a lever, pivoted on jewelled bearings. One end of the lever is kept in contact with the capsule by means of a light hairspring and a micrometer screw, which extends through the case and actuates a digital counter, which is brought into contact with the other end of the lever by the observer. Contact is indicated by a small cathode- ray tube; a continuous line of light indicates that contact is made and a broken line of light indicates that the circuit is broken. When the micrometer screw is set so that the contact is just broken the digital counter indicates the pressure in millibars and tenths. The box containing the aneroid capsules is completely airtight except for one hole, and that orifice is fitted with a damping device which restricts the response of the instrument to the rapid pressure variations caused by the rise and fall of the ship.

The Precision Aneroid Barometer Mk. 2 (as shown in Figures l and 2) is the type issued to Voluntary Observing Ships.

Installation of *the Mk. 2 aneroid barometer.* The installation of the barometer on board ship should be carried out by the Port Met. Officer. It should be mounted on a mounting plate, preferably on a fore-and-aft bulkhead. When this has been done the damping cap should be fitted. Firstly unscrew the static vent (Figure l) reverse it and screw it back in finger-tight, making sure that the O-ring on the static tube beds firmly.

Reading the Mk. 2 aneroid barometer. Press the black switch button. If the thread of light in the cathode ray indicator is broken, turn the knob so that the pressure reading decreases until the thread becomes continuous. When the light is continuous turn the knob so that the pressure reading increases until the thread of light breaks. This should be repeated to avoid any error due to overshooting. At the point where the thread of light breaks, the pressure shown in the window should be read off. If parts of two figures show equally in the tenth-of-a- millibar position the odd number should be taken. In later models of PAB the light thread is replaced by small illuminated red arrows, or triangles, above and below the window, which indicate the direction in which the knob should be turned to obtain a reading, shown by both arrows lighting up alternately.

The pressure as read must be corrected to mean sea level. First apply the correction shown on the calibration correction card supplied and then apply the correction given on the barometer correction card supplied. This must be done for all observations. (See also Table l)

TABLE 1 — Correction of millibar barometers to mean sea level

These corrections are to be **added** to the barometer readings

Height	Temperature of Air (°C) (Dry bulb in screen)											
	-15	-10	-5	0	5	10	15	20	25	30	35	40
metres	*millibars*											
5	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5
10	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1
15	2.0	1.9	1.9	1.9	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.6
20	2.6	2.6	2.5	2.5	2.5	2.4	2.4	2.3	2.3	2.3	2.2	2.2
25	3.3	3.2	3.2	3.1	3.1	3.0	3.0	2.9	2.9	2.8	2.8	2.7
30	4.0	3.9	3.8	3.8	3.7	3.6	3.6	3.5	3.4	3.4	3.3	3.3
35	4.6	4.5	4.5	4.4	4.3	4.2	4.2	4.1	4.0	3.9	3.9	3.8
40	5.3	5.2	5.1	5.0	4.9	4.8	4.7	4.7	4.6	4.5	4.4	4.4
45	6.0	5.9	5.7	5.6	5.5	5.4	5.3	5.3	5.2	5.1	5.0	4.9
50	6.6	6.5	6.4	6.3	6.2	6.0	5.9	5.8	5.7	5.6	5.6	5.5

Maintenance of the Mk. 2 aneroid barometer. The only maintenance required is the renewal of the batteries at approximately twelve-month intervals. When the indicator thread or arrow becomes dim and it is difficult to see whether or not it is broken, the batteries should be changed.

Corrections to aneroid readings

Aneroid barometers of good quality are compensated by the manufacturers, for such changes in temperature as they are likely to experience, either by leaving a calculated small amount of air in the vacuum chamber, or by use of a bimetallic lever. Such aneroids, therefore, do not require correcting for temperature. Aneroids do not require correcting for latitude, as the principle on which they are based is the balancing of atmospheric pressure by the elasticity of metal, so that the force of gravity does not come into the picture. The only corrections which should be applied to an aneroid reading are those for altitude (see Table l) and for index error where necessary.

Precautions necessary with an aneroid barometer

The instrument should be placed where it is not liable to sudden jars which may alter its index correction, rapid changes of temperature and where the sun cannot

Figure 1. Precision Aneroid Barometer Mk 2–general view, Note the housed static vent on left side beneath cap.

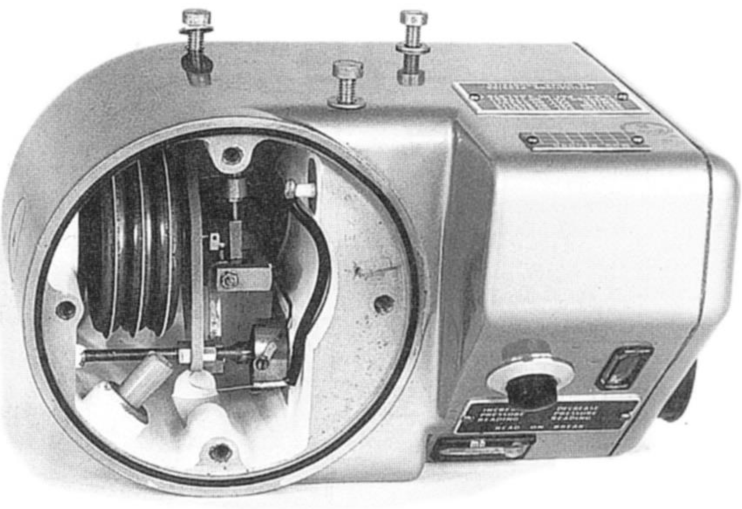

Figure 2. Precision Aneroid Barometer Mk. 2–-interior,

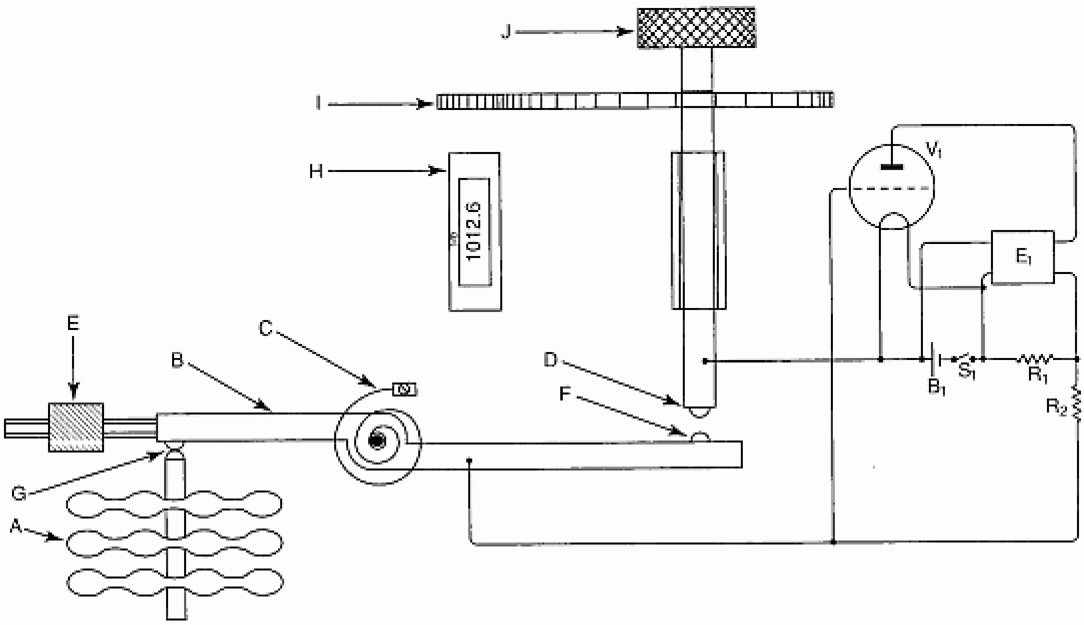

Figure 3. Precision Aneroid Barometer Mk. 2 — schematic drawing.
A — Aneroid capsule assembly, B — Pivoted bar, C — Hairspring D — Micrometer-type spindle and nut, E — Counterbalance
F — Sliding electrical contacts, G — Mechanical contacts H — Counter, I — Gearing, J — Knob, V_1 — 'Magic-eye' indicator
S_1— Switch, B_1 — Battery, 1.5 V, E_1 — Voltage converter R_1 and R_2 — Resistances

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shine directly on to it. Dial aneroids should he tapped gently before a reading is taken as the pointer is liable to stick. This is not necessary with digital precision aneroids.

All aneroids require careful comparisons with barometers whose accuracy can be relied upon, as changes in the elasticity of the metal of which the vacuum chamber is composed may cause appreciable variations in the index correction. Such changes are rare in good quality instruments. Every opportunity should be taken when the vessel is in harbour of making a comparison with a reliable barometer. With a Precision Aneroid Barometer Mk. 2 the damping cap should be removed before making a comparison with a check barometer. Comparisons against a mercury barometer while the ship is at sea are not likely to be satisfactory as the readings of a mercury barometer on a moving ship cannot be considered as reliable for this purpose.

All Port Met. Officers and many harbour and Marine Offices have a standard barometer which is available for such comparisons. A record should be kept of all barometer comparisons made on a ship; this will be useful in assessing the reliability of the instrument and the correction to be applied to dial aneroids when at sea.

Adjustment of aneroid readings

The reading of a dial aneroid may be corrected, if desired, by means of the adjusting screw at the back. Whenever such an alteration of the index correction is made, the fact should be noted, with the date. Such adjustments should, however, only be made if the index correction becomes too great; small changes in the index error of the instrument should be allowed for by altering the correction to the applied readings. No attempt should be made to alter the settings of the Met. Office Precision Aneroid Barometer Mk. 2.

THE MERCURY BAROMETER

The use of mercury barometers for measuring atmospheric pressure has been gradually phased out during recent years, in favour of the precision aneroid barometer. However, some vessels of certain countries participating in the World Meteorological Organization scheme of Voluntary Observing Ships are equipped with mercury barometers, and therefore a general description of their construction and use is included.

The principle of the mercury barometer was discovered by Evangelista Torricelli in 1643.

A simple mercury barometer (Figure 4) is made by completely filling with mercury a glass tube closed at one end and approximately 1 m in length. The open end is then immersed in a cistern also containing mercury, and the tube is held upright. The mercury column falls, leaving a vacuum at the top of the tube, until the weight of the mercury column above the level of the mercury in the cistern just balances the atmospheric pressure which is exerted on the free surface of the mercury in the cistern.

The mercury barometer only gradually passed from this original simple form to that of a practical and portable instrument and was not used by seamen until a century had elapsed.

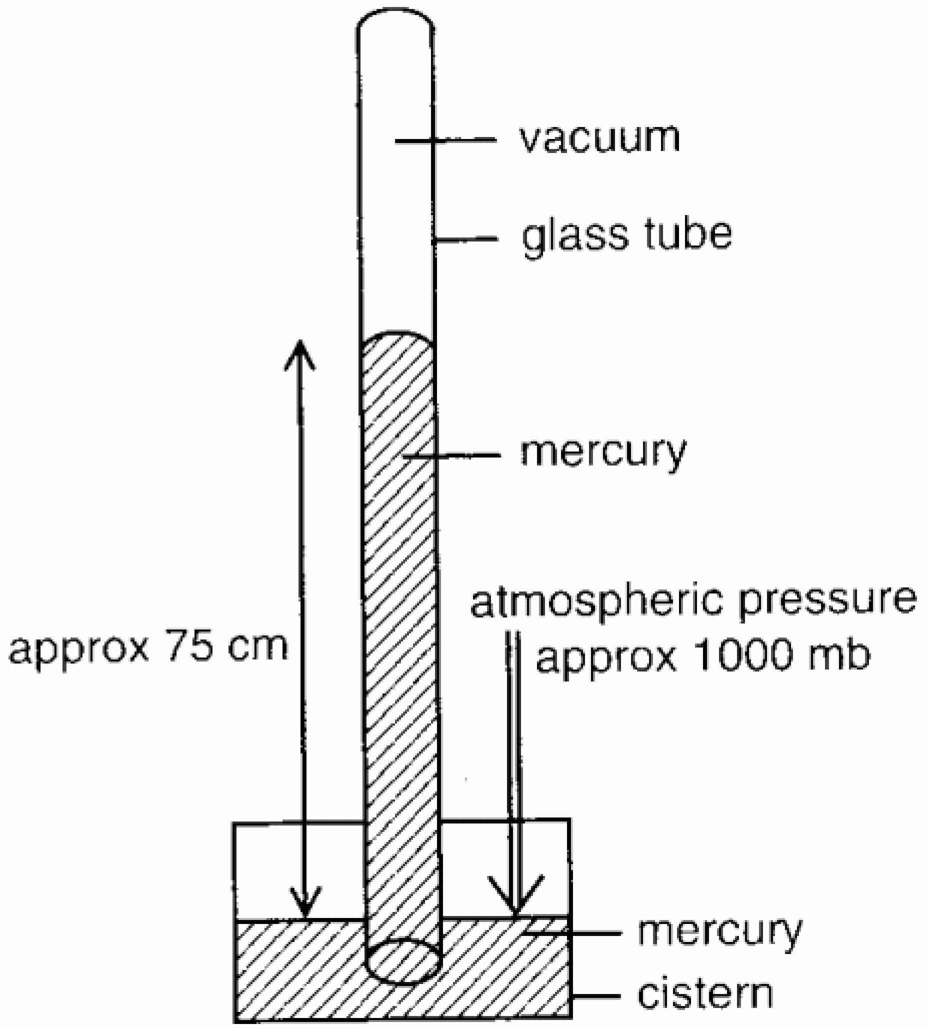


Figure 4. A simple mercury barometer.

For the purpose of ascertaining the temperature of the barometer itself, a thermometer is attached. On barometers graduated in millibars (hectopascals) the thermometer is graduated in degrees Absolute on older instruments, but in degrees Celsius on those made after 1 January 1955; on inch barometers, it is usually graduated in degrees Fahrenheit.

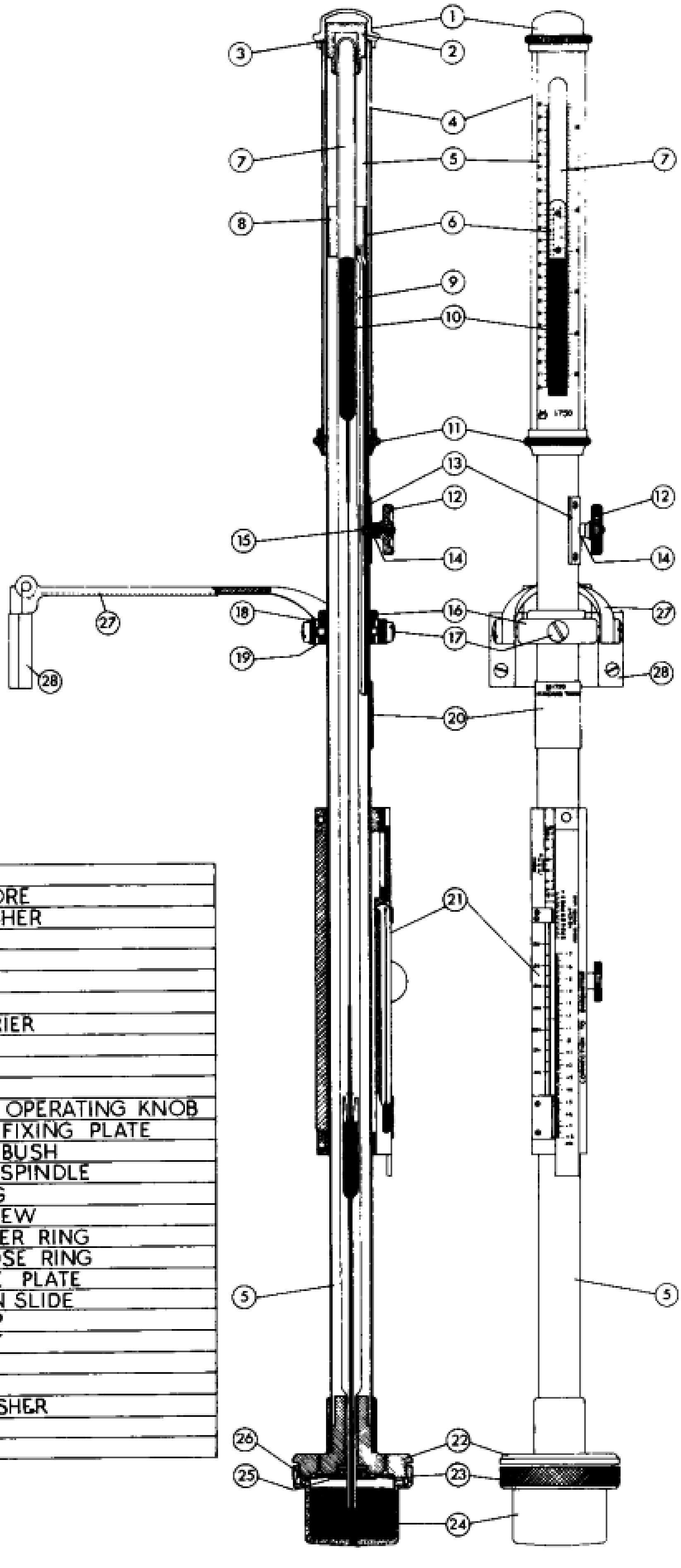
Graduation of barometer scales

From the invention of the barometer until comparatively recent times the reading was expressed as the height of the mercury column necessary to balance the atmospheric pressure at that instant. In the British Isles, atmospheric pressure was therefore expressed in inches and decimals of an inch, while countries using the metre as a unit of length gave the pressure in millimetres and decimals of a millimetre. The graduations are marked on a metal scale at the side of the instrument. Barometer scales graduated in inches are readable by vernier to a thousandth of an inch (0.001).

Pressure is force per unit area and the measurement of a force is the acceleration it would give to a body of unit mass which is free to move. In the International System of Units (SI), now adopted by most countries, the unit of force is the newton (symbol N), the force which, if applied to a mass of 1 kilogram will produce an acceleration of 1 metre per second. The unit of pressure is the pascal (symbol Pa) which is a force of I newton per square metre. Use of the millibar as a unit of pressure has been universal in the field of meteorology and is being superseded by the hectopascal, as decreed by the World Meteorological Organization. The millibar continues to be used by the Met. Office as it is familiar to users and will continue to be printed as such in Met. Office marine publications.

1 mb = 1 millibar = 100 pascals = 1 hectopascal = I hPa.

In mercury barometers the pressure exerted by the atmosphere is balanced against a column of mercury. Any change in the length of the mercury column is



1	TOP CAP
2	SCREWED CORE
3	LEATHER WASHER
4	GLASS COVER
5	BARREL
6	VERNIER
7	MARINE TUBE
8	VERNIER CARRIER
9	RACK
10	MERCURY
11	BOTTOM CAP
12	PINION GEAR OPERATING KNOB
13	" " FIXING PLATE
14	" " BUSH
15	" " SPINDLE
16	GIMBAL RING
17	" SCREW
18	" OUTER RING
19	" LOOSE RING
20	TEMPERATURE PLATE
21	CORRECTION SLIDE
22	CISTERN CAP
23	" NUT
24	CISTERN
25	GLAND
26	LEATHER WASHER
27	ARM
28	BRACKET

Figure 5. The Kew-pattern marine barometer.

accompanied by a change in the level of the mercury in the cistern. The height of the mercury column depends on atmospheric pressure, density of the mercury and gravity. Standard conditions are laid down under which a barometer should read correctly. These are density of mercury at a temperature of 0 ºC, 13 595.1 kilograms per cubic metre (kg/m^3), and a conventional datum for gravity of 9.80665 metres per second per second (m/s^2).

The Kew-pattern marine barometer

The Kew-pattern marine barometer was the standard issue by the Met. Office prior to the introduction of the precision aneroid barometer. In this type the level of the mercury in the cistern does not have to be adjusted as the scale on the barometer is constructed to allow for changes in the level of the mercury cistern.

The Kew-pattern barometer consists of a glass tube and cistern enclosed in a metal protecting case (Figure 6). In the upper part of the cistern are one or more small holes which admit the air, and a leather washer, permeable to air, which prevents the mercury from escaping, and also keeps out dust. The bore of the glass tube is considerably constricted for the greater part of its length, and, for part of this constriction, is reduced to a fine capillary. The object of these constrictions is to reduce the amount of 'pumping', i.e. oscillations of the top of the mercury column, caused by the movements of the ship and by gusts of wind. At the top of the mercury column the bore of the tube is greater; this minimizes the effect of 'capillarity'* on the height of the centre of the mercury column, but leaves the upper surface of the column sufficiently convex to facilitate accurate reading. An air-trap in the tube prevents air from rising into the space above the mercury column, which should be an almost perfect vacuum. On the metal protecting case is a scale, with a vernier for reading the height of the mercury.

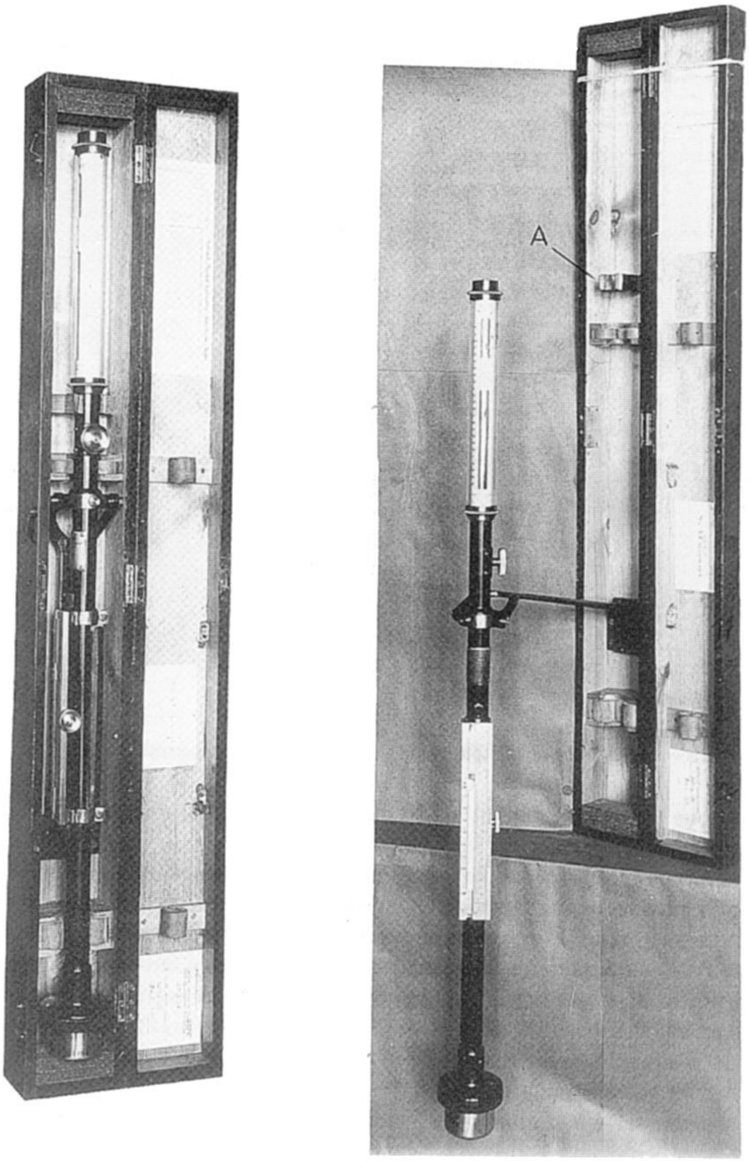


Figure 6. The Kew-pattern marine barometer and its stowage.

Corrections to mercury barometers

The procedures for preparing corrections for these barometers are no longer dealt with in this handbook. For those interested in determining them, however, reference should be made to the 10th edition of the *Marine Observer's Handbook* (1977, reprinted to 1993), obtainable from the Marine Division, Bracknell.

*Capillarity is the tendency of liquids in narrow tubes to rise above or fall below the hydrostatic level. This tendency depends on the relative attraction of the molecules of the liquid for one another and for the molecules of the material of the tube. The narrower the tube, the greater the tendency to rise or fall, so that the effect is particularly well marked in hair-like or capillary tubes, hence the word 'capillarity'. If the liquid wets the solid material, it will rise in a glass tube, but if not, it will be depressed. In the case of water in a glass tube, therefore, the water column is raised, particularly at the edge, while the reverse is the case with mercury in a glass tube, since mercury does not wet glass